IN THE CLAIMS

1   1. (currently amended) A method of obtaining nuclear magnetic resonance signals from

2   a fluid obtained from an earth formation, comprising:

3   (a)   conveying said fluid into a nuclear magnetic resonance (NMR) sensor in a

4   borehole in said earth formation;

5   (b)   enhancing a polarization of a nuclear spin of a nucleus occurring in said

6   fluid <u>to a hyperpolarized state beyond that attainable for any atomic</u>

7   <u>nucleus at thermal equilibrium in the applied magnetic field</u>; and

8   (c)   using said NMR sensor for obtaining NMR signals from said fluid.

9

1   2. (original)The method of claim 1 wherein enhancing said polarization of said nuclear

2   spin is based at least in part on the Overhauser effect (OE).

3

1   3. (original)The method of claim 1 wherein enhancing said polarization of said nuclear

2   spin is based at least in part on the Nuclear Overhauser Effect (NOE).

3

1   4. (original) The method of claim 1 wherein enhancing said polarization of said nuclear

2   spin is based at least in part on optical pumping.

3

1   5. (original) The method of claim 1 wherein enhancing said polarization of said nuclear

2   spin is based at least in part on a Spin Induced Nuclear Overhauser Effect

3   (SPINOE).

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1   6. (original) The method of claim 1 wherein enhancing said nuclear spin polarization

2   further comprises:

3   (i)   introducing a polarizing agent into said fluid; and

4   (ii)   polarizing a spin of said polarizing agent, and

5   (iii)   transferring a polarization of said polarized agent to said nuclear spin.

6

1   7. (original) The method of claim 1, further comprising conveying said sensor downhole

2   on a wireline device.

3

1   8. (original) The method of claim 1, further comprising conveying said sensor downhole

2   on a measurement-while-drilling tool.

3

1   9. (original) The method of claim 6, wherein said polarizing agent further comprises a

2   noble gas.

3

1   10. (original) The method of claim 9, wherein said polarizing agent further

2   comprises xenon.

3

1   11. (original) The method of claim 1, wherein said nucleus occurring in said fluid further

2   comprises a carbon-13 nucleus present in at least one of: i) an aliphatic

3   hydrocarbon , ii) an aromatic hydrocarbon, , iii) a connate formation fluid, and,

4   (iv) a mud filtrate

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1   12. (original)The method of claim 6, wherein said polarizing said spin of said polarizing

2   agent further comprises a spin exchange with an intermediate material.

3

1   13. (original) The method of claim 12 wherein said intermediate material comprises

2   rubidium.

3

1   14. (original) The method of claim 12 further comprising irradiating said intermediate

2   material with a laser to move electrons of said intermediate material to a higher

3   quantum state

4

1   15. (currently amended) The method of claim 1, wherein obtaining said nuclear magnetic

2   resonance signal further comprises:

3   i)   ~~conveying said fluid within a chamber of said sensor;~~

4   ~~ii)~~   providing a substantially homogeneous static magnetic field in said

5   chamber;

6   ~~iii)~~ ii) applying a radio frequency pulse sequence to said fluid with at least one

7   transmitter; and

8   ~~iv)~~ iii) obtaining NMR signals from said fluid in response to said radio frequency

9   pulse sequence at at least one receiver antenna.

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1   16. (original) The method of claim 1 wherein obtaining said NMR signals further

2   comprises obtaining spin echo signals.

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1   17. (original) The method of claim 16 further comprising:

2   (i)   summing amplitudes of said spin echo measurements

3   (ii)   spectrally analyzing said summed amplitudes;

4   (iii)   determining whether aromatic hydrocarbons are present in said fluid

5   sample by measuring an amplitude of said spectrally analyzed summed

6   amplitudes at about 130 parts per million shift from a ^{13}C resonant

7   frequency and determining whether aliphatic hydrocarbons are present in

8   said fluid sample by measuring an amplitude of said spectrally analyzed

9   summed amplitudes at about 30 parts per million frequency shift from said

10   ^{13}C resonant frequency.

11

1   18. (original) The method of claim 1 wherein said NMR signals comprise a free induction

2   decay.

3

1   19. (currently amended) The method of claim 1 wherein said NMR signals are C̶W̶

2   continuous wave NMR signals t̶o̶ ̶o̶b̶t̶a̶i̶n̶ ̶f̶r̶e̶q̶u̶e̶n̶c̶y̶ ̶s̶p̶e̶c̶t̶r̶a̶ from which chemical

3   shift information is obtained to analyze the chemical composition of the sample

4   under test.

5

1   20. (original) The method of claim 18 where the free induction decay is transformed into

2   a frequency spectrum for analyzing chemical composition from the chemical shift

3   information.

4

1   21. (original) The method of claim 1 wherein said NMR signals are associated with a

2   nuclear spin of ^{13}C.

3

1   22. (original) The method of claim 15 wherein said NMR signals are associated with a

2   nuclear spin of ^{13}C.

3

1   23. (original) The method of claim 22 wherein providing said substantially

2   homogeneous static magnetic field further comprises using additional NMR

3   signals associated with ^{1}H.

4

1   24. (original) The method of claim 15 wherein providing said substantially

2   homogeneous static magnetic field further comprises using additional NMR

3   signals associated with ^{1}H.

4

1   25. (currently amended) The method of claim 2 further comprising radiating RF into an

2   <u>Electron Spin Resonance (ESR)</u>-active agent at an ESR frequency of said agent

3   and thereby enhancing the spin polarization of atomic nuclei.

4

1   26. (original) The method of claim 3 further comprising changing a nuclear spin

2   polarization of carbon-13 nuclei in said fluid by radiating RF at a NMR

3   frequency of hydrogen nuclei.

4

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1 27.   (withdrawn) A method of obtaining a parameter of interest of an earth formation,

2   comprising:

3   (a)   using a magnet on a nuclear magnetic resonance (NMR) sensor of a

4   downhole logging tool for aligning spins of nuclei in a region of interest

5   of said earth formation;

6   (b)   polarizing nuclear spins of a polarizing agent carried in a chamber on said

7   logging tool ;

8   (c)   introducing said polarizing agent into said earth formation and enhancing

9   alignment of spins of said nuclei in said region of interest;

10   (d)   applying a radio frequency (RF) pulse sequence to said earth formation

11   with at least one transmitter on said NMR sensor; and

12   (e)   obtaining NMR signals from said region of interest in response to said

13   radio frequency pulse sequence at at least one receiver antenna.

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1 28.   (withdrawn) The method of claim 27 wherein said obtained NMR signals

2   comprise a free induction decay.

3

1 29.   (withdrawn) The method of claim 27 wherein said obtained NMR signals

2   comprise spin echo signals.

3

1 30.   (withdrawn) The method of claim 29 wherein said RF pulse sequence comprises

2   an excitation pulse and a plurality of refocusing pulses.

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1   31.   (withdrawn) The method of claim 30 wherein said excitation pulse has a tip angle

2   of substantially equal to 90^{0}.

3

1   32.   (withdrawn) The method of claim 30 wherein said plurality of refocusing pulses

2   have tip angles substantially equal to 180^{0}.

3

1   33.   (withdrawn) The method of claim 30 wherein said plurality of refocusing pulses

2   have tip angles between 90^{0} and 180^{0}.

3

1   34.   (withdrawn) The method of claim 29 further comprising using a processor

2   associated with said   logging tool for obtaining a longitudinal relaxation time

3   (T_1) distribution of said earth formation.

4

1   35.   (withdrawn) The method of claim 29 further comprising using a processor

2   associated with said logging tool for obtaining a transverse relaxation time (T_2)

3   distribution of said earth formation

4

1   36.   (withdrawn) The method of claim 29 wherein said parameter of interest is at least

2   one of (i) porosity, (ii) clay bound water, (iii) bound volume irreducible, and, (iv)

3   permeability.

4

1   37.   (withdrawn) The method of claim 27 wherein said polarizing agent comprises a

2   noble gas.

8

3

1   38.   (withdrawn) The method of claim 27 wherein said noble gas comprises Xenon.

2

1   39.   (withdrawn) The method of claim 27 wherein polarizing said nuclear spins of said

2   polarizing agent further comprises a spin exchange with an intermediate material.

3

1   40.   (withdrawn) The method of claim 39 wherein said intermediate material

2   comprises rubidium.

3

1   41.   (withdrawn) The method of claim 39 further comprising irradiating said

2   intermediate material with a laser to move electrons of said intermediate material

3   to a higher quantum   state.

4

1   42. (currently amended) An apparatus for use in a borehole in an earth formation for

2   obtaining nuclear magnetic resonance signals from a fluid obtained from said

3   formation, comprising:

4   (a)   a nuclear magnetic resonance sensor;

5   (b)   a device which enhances a polarization of a nuclear spin of a nucleus

6   occurring in said fluid to a hyperpolarized state beyond that attainable for

7   any atomic nucleus at thermal equilibrium in the applied magnetic field;

8   and

9   (c)   a processor which analyzes NMR signals obtained by said NMR sensor

10   from said fluid.

9 .

11

1   43. (original) The apparatus of claim 42 wherein said device for enhancing said

2   polarization of said nuclear spin uses the Overhauser effect (OE).

3

1   44. (original) The apparatus of claim 42 wherein said device for enhancing said

2   polarization of said nuclear spin uses the Nuclear Overhauser Effect (NOE).

3

1   45. (original) The apparatus of claim 42 wherein said device for enhancing said

2   polarization of said nuclear spin uses optical pumping.

3

1   46. (original) The apparatus of claim 42 wherein said device for enhancing said

2   polarization of said nuclear spin uses a Spin Induced Nuclear Overhauser Effect

3   (SPINOE).

4

1   47. (original) The apparatus of claim 42 wherein said device for enhancing said nuclear

2   spin further comprises:

3   (i)   an arrangement for introducing a polarizing agent into said fluid; and

4   (ii)   an arrangement for polarizing a spin of said polarizing agent,

5

1   48. (original) The apparatus of claim 47, wherein said polarizing agent further comprises

2   a noble gas

3

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1   49. (original) The apparatus of claim 48, wherein said polarizing agent further comprises

2   xenon.

3

1   50. (original) The apparatus of claim 42, wherein said nucleus occurring in said fluid

2   further comprises a carbon-13 nucleus present in at least one of: i) an aliphatic

3   hydrocarbon , ii) an aromatic hydrocarbon, , iii) a connate formation fluid, and,

4   (iv) a mud filtrate.

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1   51. (original) The apparatus of claim 47, wherein said polarizing said spin of said

2   polarizing agent further comprises a spin exchange with an intermediate material.

3

1   52. (original) The apparatus of claim 51 wherein said intermediate material

2   comprises rubidium.

3

1   53. (previously presented) The apparatus of claim 51 further comprising a laser which

2   moves electrons from the S to the P quantum state of said intermediate

3   material.

4

1   54. (previously presented) The apparatus of claim 42, further comprising:

2   i)   a fluid chamber;

3   ii)   a magnet arrangement which provides a substantially homogeneous static

4   magnetic field in said chamber;

5   iii)   a transmitter which applies a radio frequency magnetic field to said fluid;

11

6   iv)   a receiver which obtains NMR signals from said fluid in response to said

7   radio frequency magnetic field.

8

1   55. (original) The apparatus of claim 42 wherein said NMR signals further comprise

2   obtaining spin echo signals.

3

1   56. (previously presented) The apparatus of claim 55 further comprising:

2   a processor which:

3   (i)   sums amplitudes of said spin echo measurements;

4   (ii)   spectrally analyzes said summed amplitudes; and

5   (iii)   determines whether aromatic hydrocarbons are present in said fluid

6   sample by measuring an amplitude of said spectrally analyzed summed

7   amplitudes at a first frequency shift from a ^{13}C resonant frequency and

8   determining whether aliphatic hydrocarbons are present in said fluid

9   sample by measuring an amplitude of said spectrally analyzed summed

10   amplitudes at a second frequency shift from said ^{13}C resonant frequency.

11

1   57. (original) The apparatus of claim 42 wherein said NMR signals comprise a free

2   induction decay.

3

1   58. (original)The apparatus of claim 57 where said processor transforms the free

2   induction decay into a frequency spectrum for analyzing chemical composition

3   from the chemical shift information.

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1   59. (currently amended) The apparatus of claim 42 where said NMR signals comprise a
2   CW frequency spectrum for.
3

4   60. (original) The apparatus of claim 42 wherein said NMR signals are associated with a
2   nuclear spin of ^{13}C.
3

1   61. (original) The apparatus of claim 53 wherein said NMR signals are associated with a
2   nuclear spin of ^{13}C.
3

1   62. (original) The apparatus of claim 43 wherein said NMR sensor includes a transmitter
2   that applies an RF magnetic field to said fluid at an electron spin resonance
3   (ESR) frequency of an ESR-active agent
4

1   63. (original) The apparatus of claim 44 wherein said NMR sensor includes a
2   transmitter that applies an RF magnetic field to said fluid at nuclear resonance
3   frequency of hydrogen nuclei in said fluid.
4

1   64.   (withdrawn) An apparatus for obtaining a parameter of interest of an earth
2   formation, comprising:
3   (a)   a magnet on a nuclear magnetic resonance (NMR) sensor of a
4   downhole logging tool for aligning spins of nuclei in a region of interest
5   of said earth formation;

13

6   (b)   a chamber on said logging tool containing a polarizating agent;

7   (c)   a device for polarizing spins of said polarizing agent and conveying said

8   polarizing agent into said earth formation thereby enhancing alignment of

9   spins of said nuclei in said region of interest;

10   (d)   a transmitter for applying a radio frequency (RF) pulse sequence to said

11   earth formation;

12   (e)   a receiver for obtaining NMR signals from said region of interest in

13   response to said radio frequency pulse ; and

14   (f)   a processor for determining from said NMR signals a parameter of interest

15   of said earth formation.

16

1   65.   (withdrawn) The apparatus of claim 64 wherein said obtained NMR signals

2   comprise a free induction decay.

3

1   66.   (withdrawn) The apparatus of claim 65 wherein said obtained NMR signals

2   comprise spin echo signals

3

1   67.   (withdrawn) The apparatus of claim 66 wherein said RF pulse sequence

2   comprises an excitation pulse and a plurality of refocusing pulses.

3

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1   68.   (withdrawn) The apparatus of claim 67 wherein said excitation pulse has a tip

2   angle of substantially equal to 90^0.

3

1   69.   (withdrawn) The apparatus of claim 64 wherein said processor obtains a

2   longitudinal relaxation time (T_1) distribution time of said earth formation.

3

1   70.   (withdrawn) The apparatus of claim 64 wherein said parameter of interest is at

2   least one of (i) porosity, (ii) clay bound water, (iii) bound volume irreducible, and,

3   (iv) permeability.

4

1   71.   (withdrawn) The apparatus of claim 64 wherein said polarizing agent comprises a

2   noble gas.

3

1   72.   (withdrawn) The apparatus of claim 71 wherein said noble gas comprises xenon.

2

1   73.   (withdrawn) The apparatus of claim 64 wherein polarizing said nuclear spins of

2   said polarizing agent further comprises a spin exchange with an intermediate

3   material.

4

1   74.   (withdrawn) The apparatus of claim 73 wherein said intermediate material

2   comprises rubidium.

3

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1   75.   (withdrawn) The apparatus of claim 73 further comprising a laser for irradiating

2   said intermediate material to cause transitions from the S to the P quantum state of

3   electrons of said intermediate material.

4

1   76. (currently amended) A system for obtaining nuclear magnetic resonance signals from

2   a fluid obtained from an earth formation, comprising:

3   (a)   a logging tool including a nuclear magnetic resonance (NMR) sensor;

4   (b)   a first conveyance device which conveys said fluid into a chamber of said

5   (NMR) sensor;

6   (c)   an arrangement which enhances a polarization of a nuclear spin of a

7   nucleus occurring in said fluid to a hyperpolarized state beyond that

8   attainable for any atomic nucleus at thermal equilibrium in the applied

9   magnetic field;

10   (d)   a processor which determines from signals obtained by said NMR sensor a

11   property of said fluid; and

12   (e)   a second conveyance device which conveys said logging tool into said

13   earth formation.

14

1   77. (currently amended) The system of claim 76 wherein said second conveyance device

2   in (e) is selected from the group consisting of (i) a wireline, and, (ii) a drilling

3   tubular, and, (iii) coiled tubing.

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1   78. (original)The system of claim 76 wherein said arrangement in (c) uses at least one of

2   (i) the Overhauser Effect (OE), (ii) the Nuclear Overhauser Effect (NOE), (iii)

3   optical pumping or (iv) Spin Polarization Induced Nuclear Overhauser Effect

4   (SPINOE).

5

1   79. (original) The system of claim 76 wherein said arrangement in (c) uses at least one of

2   (i) a noble gas, (ii) xenon, (iii) an alkaline metal, and, (iv) rubidium.

3

1   80. (previously presented) The system of claim 76 further comprising a laser optically

2   pumps at least one of (i) a noble gas, and, (ii) xenon.

3

1   81.   (withdrawn) A method of using a logging tool for analyzing a fluid of an earth

2   formation, the method comprising:

3   (a)   dissolving a polarizing agent into said fluid;

4   (b)   using an NMR sensor on said logging tool for obtaining NMR signals

5   from said dissolved polarizing agent.

6

1   82.   (withdrawn) The method of claim 81 wherein said dissolving of said polarizing

2   agent is done   in the earth formation.

3

1   83.   (withdrawn) The method of claim 81 wherein said dissolving of said polarizing

2   agent is done in a fluid sample chamber on said logging tool, the method further

17

3   comprising recovering said formation fluid from said earth formation using a fluid

4   sampling device on said logging tool.

5

1 84.   (withdrawn) The method of claim 81 wherein said NMR signals correspond to

2   free induction decay of a nucleus of said polarizing agent.

3

1 85.   (withdrawn) The method of claim 84 further comprising chemical shift NMR

2   analysis of said NMR signals.

3

1 86.   (withdrawn) The method of claim 81 where said NMR signals comprise of a CW

2   frequency spectrum to obtain chemical shift information.

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